NISTTech

Frequency Comb Cavity Enhanced Spectroscopy

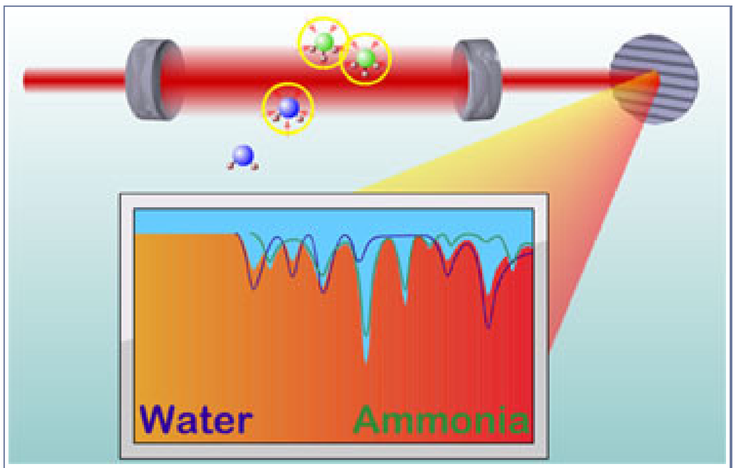
Measuring Trace Amounts of Atomic and Molecular Species

Description

Accurately measure trace amounts of different atomic and molecular species in a spectroscopic apparatus. This approach combines the technology of a broadband optical frequency comb with that of a special optical cavity. The key advantage over conventional spectroscopic methods is the combining of performance features such as large spectral bandwidth, high spectral resolution, high sensitivity, and fast time in a single apparatus.

This measurement technology has potential applications in many advanced fields of science that require the identification or manipulation of atoms or molecules, such as detection of toxic biochemical agents, studies of ultrafast dynamics and quantum computing. With refinements, the frequency comb technology might be applied in many other research fields and technologies, from medical tests in doctor's offices, to synchronization of advanced telecommunications systems, to remote detection and range measurements for manufacturing or defense applications.

Images



The technique uses infrared laser light in many different colors (frequencies) to identify trace levels of different molecules at the same time. For example, water molecules (blue) and ammonia molecules (green) absorb light at very specific characteristic frequencies. The pattern of frequencies absorbed forms a "signature" for identifying the molecules and their concentrations. Credit: Jeffrey Fal, JILA

Applications

- **Forensics and Research**
  Real-time detection of trace amounts of molecular species.
- **Homeland Security**
  Security staging area in an airport for detection of trace amounts of molecules found in explosives or biologically hazardous materials.
- **Medical and Environmental**
  Development opportunity to create a portable sampling tool providing detection capability at the 1 part per billion level, enabling, for example, a non-obtrusive on-site breath analysis for monitoring diseases such as renal failure and cystic fibrosis.

Advantages

- **Better and More Detailed Observations**
  Large spectral bandwidth allowing observation of energy level. High spectral resolution for the identification and quantitative analysis.
- **Greater Sensitivity and Fast**
  High sensitivity for detection of trace amounts of atoms or molecules. Fast spectral acquisition time taking advantage of high sensitivity.

Abstract

We invent and demonstrate a qualitatively new form of cavity ringdown spectroscopy utilizing a broad bandwidth optical frequency comb coherently coupled to a high finesse optical cavity inside which molecular samples are located. 125,000 optical comb components, each coupled into a specific longitudinal cavity mode, undergo ring down decays when the cavity input is shut off This provides sensitive intracavity absOlption information simultaneously available across 100 nm in the visible and near IR spectral region. By placing various atomic and molecular species (Ar, C2H2, O2, H20, NH3) inside the cavity, we demonstrate realtime,
quantitative measurements of the trace presence, transition strengths and linewidths, and population redistributions due to collisions and temperature changes. This novel capability to sensitively and quantitatively monitor multispecies molecular spectra over a large optical bandwidth in real-time provides a new spectroscopic paradigm for studying molecular vibrational dynamics, chemical reactions, and trace analysis.

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Related Items

- Optical Frequency Combs
- Article: JILA Unveils Improved 'Molecular Fingerprinting' for Trace Gas Detection

References

- U.S. Patent # 7,538,881
- Docket: 06-004

Status of Availability

This invention is available for licensing.

Last Modified: 12/16/2010